Asymmetric switching and charge transport in AFLC-devices with dissimilar alignment layers

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1. Asymmetric antiferroelectric liquid crystal devices

Surface stabilized antiferroelectric liquid crystal (AFLC) devices with dissimilar alignment layers on the two surfaces are characterized by a shift in the electro-optical response [1] so that it is symmetric with respect to a nonzero voltage (figure 1). Because of this shift, the switching state of a pixel which is initially set by applying a short, *selection*, voltage pulse, may be maintained without applying any holding, *bias*, voltage. The stability at zero volts, together with the inherent range of grey levels, typical for antiferroelectric liquid crystals, has some potentially very interesting applications.

Generally, the magnitude of the voltage shift changes slowly over time, depending on the driving conditions and the materials used. This varying asymmetry is an important obstacle for the implementation of this technology in real devices.

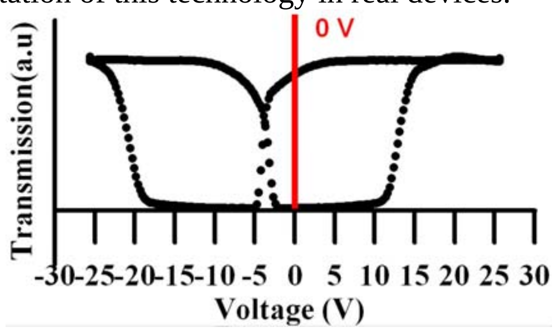

Fig. 1. Asymmetric transmission–voltage characteristic of an AFLC cell with dissimilar alignment layers.

2. The influence of charge in asymmetric AFLC devices

Charges in AFLCs can considerably influence the switching behavior of the device [2][3]. Measurements of the electric current flowing towards the electrodes of the device when a voltage step is applied can elucidate the nature and the behavior of these charges [4]. From the transient part of the current, the concentration and mobility of the charges can be obtained. The steady state current provides information about the source of the charges (as a result of reactions in the bulk or at the surfaces). Previous work [5] related the asymmetry of the transmission curve, and its change over time, with a slow buildup and release of adsorbed surface charge at the interfaces between the liquid crystal and the alignment layers. A model involving leakage through and adsorption at the alignment layers was proposed to explain transmission and current measurements on devices with a rubbed nylon on one substrate and obliquely evaporated SiOx on the other substrate.

3. Current measurements on asymmetric AFLC devices

In this work, we present current measurements on surface stabilized AFLC cells with nylon as an alignment layer on one electrode, and a number of different materials on the other substrate. The investigated materials are silicon oxide, SLS (slippery surface) and PEDOT:PSS (an organic semiconductor material). Analysis of the transient current shows that the concentration of free charge in the liquid crystal is relatively low (<10^{18} m^{-3}), and insufficient to considerably influence the electric field. The steady state current is however quite big. These observations are qualitatively consistent with the model proposed in [5], where adsorbed (not free) charge, resulting from leakage through the alignment layers, is responsible for the voltage shift. The relation between the measured steady state current and the applied voltage is dependent on the nature of the used material, and is not in all cases predicted well by the model in [5]. In some cases we measure a linear dependence of the current on the voltage (as predicted in [5]), but in other cases the relation is quadratic (see figure 2). These measurements indicate that the model should be adapted to accurately describe the influence of charge in asymmetric AFLC devices for all materials.

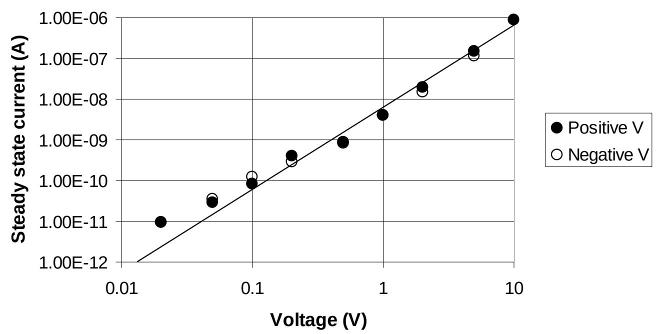

Fig. 2. A typical measurement of the steady state current as a function of applied voltage

4. References

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